

Learning & Memory

Episodic Memory



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What is Episodic Memory?

Endel Tulving

◆ *"Conscious recollection of specific past events"*

◆ **Contrasted with Semantic Memory**

- *"Accumulated knowledge that is not tied to any particular event but is also subject to conscious recollection"*

◆ **Recollection vs. Familiarity**



Table 2. Relations among human memory systems

Cohen and Squire	Tulving
<pre>graph TD Memory --> Procedural Memory --> Declarative Declarative --> Episodic Declarative --> Semantic</pre>	<pre>graph TD Episodic --> Semantic Semantic --> Procedural</pre>

Note: *Arrows* are to be interpreted as "subdivided into" in Cohen and Squire's scheme, and as "embedded in" or "depends on" in Tulving's scheme

Properties of Episodic Memory

- ◆ Relevant to our personal lives
- ◆ Temporally organized
 - “mental time travel” (Tulving, 1983)
- ◆ *Autonoetic & Noetic Consciousness*
- ◆ Remembering vs. Knowing

TABLE 1
A schematic diagram of the relations between
memory systems and varieties of
consciousness

Memory system		Consciousness	
Episodic	↔	Autonoetic	
↓		↓	
Semantic	↔	Noetic	
↓		↓	
Procedural	↔	Anoetic	

Remember-Know Paradigm (Tulving, 1972)

◆ Standard Recognition + Extra Judgment

1. Study: Learn a list of words.
2. Recognition Test: Judge a list of words as 'old' or 'new'
3. For 'old' words, decide if you:
 1. Remember
 2. Know



◆ Instructions For Responding

- Remember: Conscious recollection of the item on the list.
- Know: Abstract knowledge that the item was on the study list. Akin to *familiarity*; there is no specific detail associated with this memory.

Autobiographical Memory

◆ Is it episodic memory?

- Important to identity

◆ Diary Studies (e.g., Marigold & Linton, 1975)

- Memory for unique and emotional events

◆ Childhood amnesia

◆ Reminiscence bump

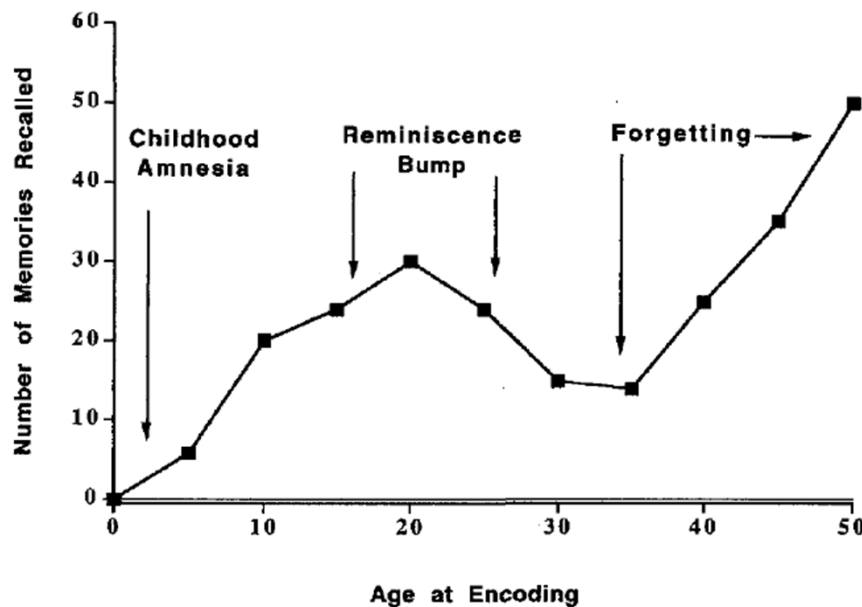


Figure 2. Idealized representation of the life span retrieval curve.



Dual Process Theories

◆ Recollection

- Meaning match
- Slow, strategic

◆ Familiarity

- Perceptual match
- Fast, automatic

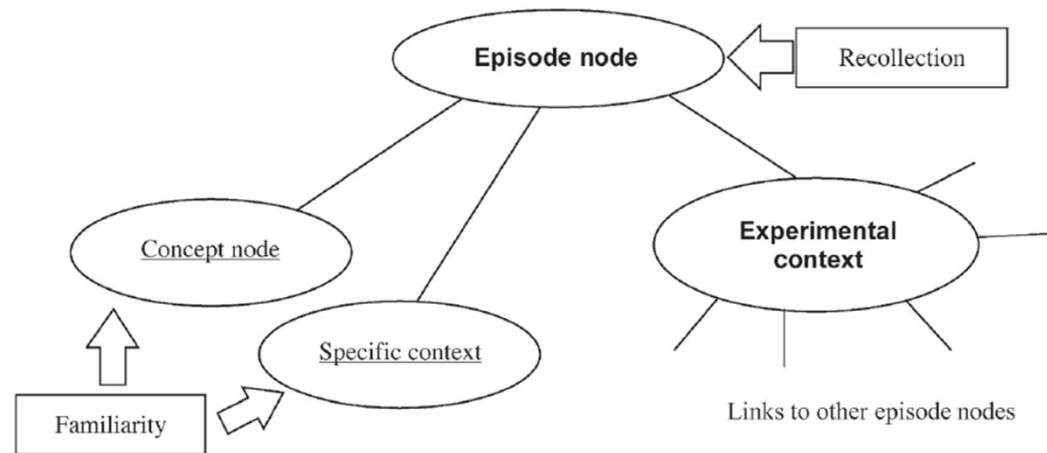
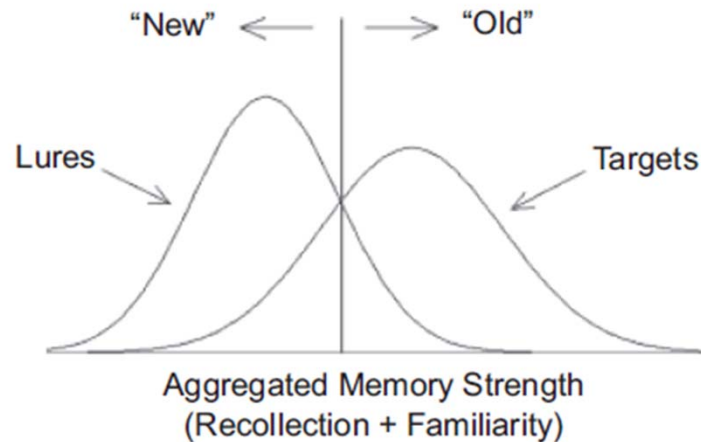


Figure 1. Schematic representation of how information is stored in memory according to the SAC model.



Converging Evidence for Dual Process

◆ Recollection & Familiarity Paradigms

- Free recall,

◆ Remember vs. Know

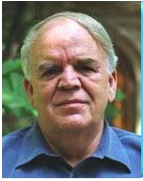
- Tulving, 1972

◆ Process Dissociation Procedure

- Jacoby, 1991

◆ Receiver Operating Characteristic (ROC)





Process Dissociation Procedure

◆ Does not assume task = process (Jacoby, 1991)

- Free recall & Recollection
- Word stem completion & Familiarity/Automatic Memory

◆ Inclusion-Exclusion Tests

Method

• Inclusion test condition

old { words presented as anagram in phase 1
words presented to be read in phase 1
words heard in phase 2

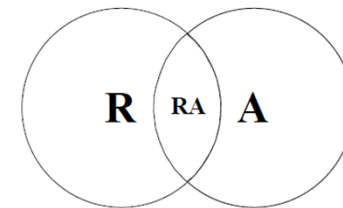
• Exclusion test condition

old only words heard in phase 2

Subjects were all in full attention

Recollection: conscious remembering

Automatic: unconscious remembering



Assumptions:

Recollection (R) and Automatic (A)
are independent and do not change
across inclusion and exclusion tests

Receiver Operating Characteristics (ROC)

◆ Hits, False Alarms, and Confidence

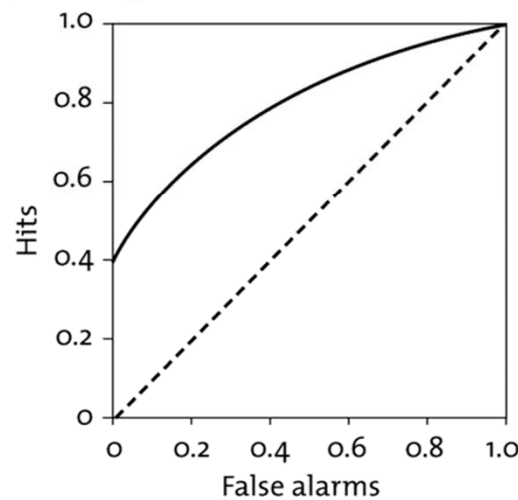
◆ Recollection

- asymmetrical
- Straight

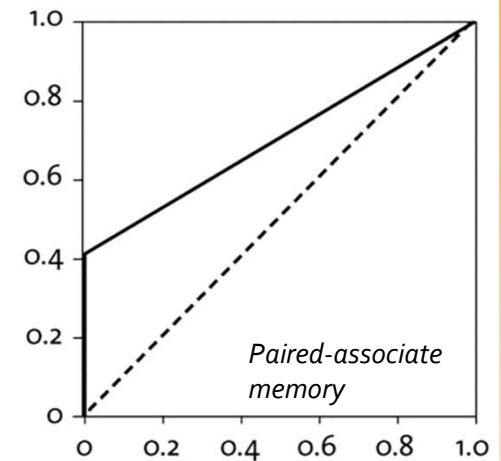
◆ Familiarity

- symmetrical
- curvilinear

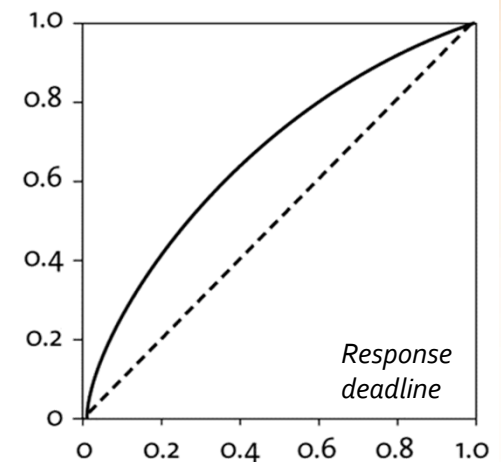
(A) Overall performance



(B) Recollection



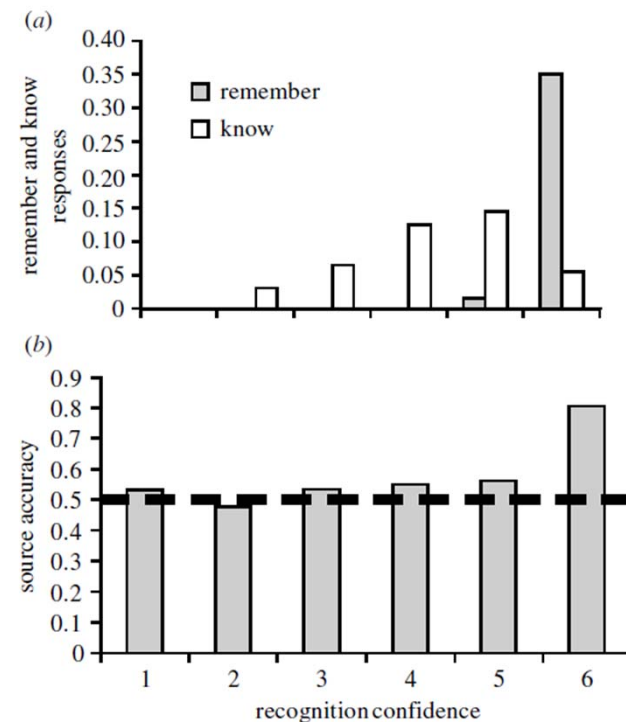
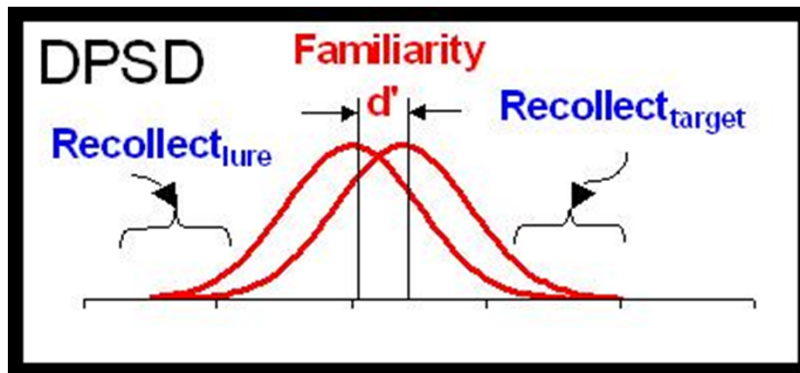
(C) Familiarity



Receiver Operating Characteristics (ROC)

◆ Remember/Know and Source Memory

- Is recollection a threshold process?



Receiver Operating Characteristics (ROC)

◆ Paired-Associate Paradigm

- Recombined vs. Intact Pairs (e.g., Yonelinas, 1997)

Study:
train-cup
phone-clock
grape-curtain

Test:
train-cup
vs.
grape-clock

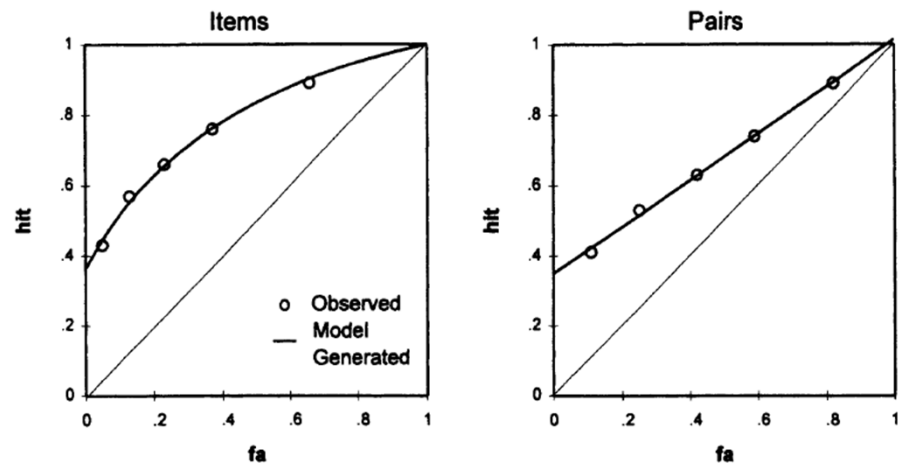


Figure 2. ROCs for item and associative (pairs) recognition plotted along with the functions generated by the dual-process model for Experiment 1.



NEUROLOGICAL BASIS OF EPISODIC MEMORY

ROCs and Amnesia

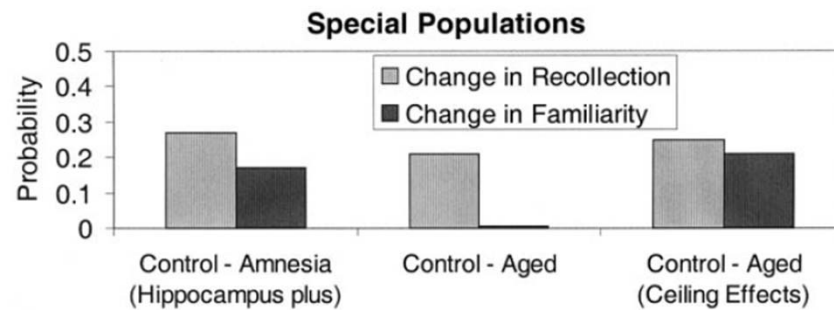


FIG. 5. The average change in recollection and familiarity estimates for special populations compared to control subjects.

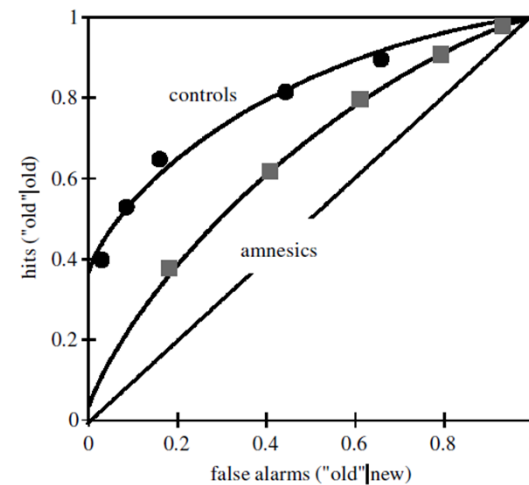
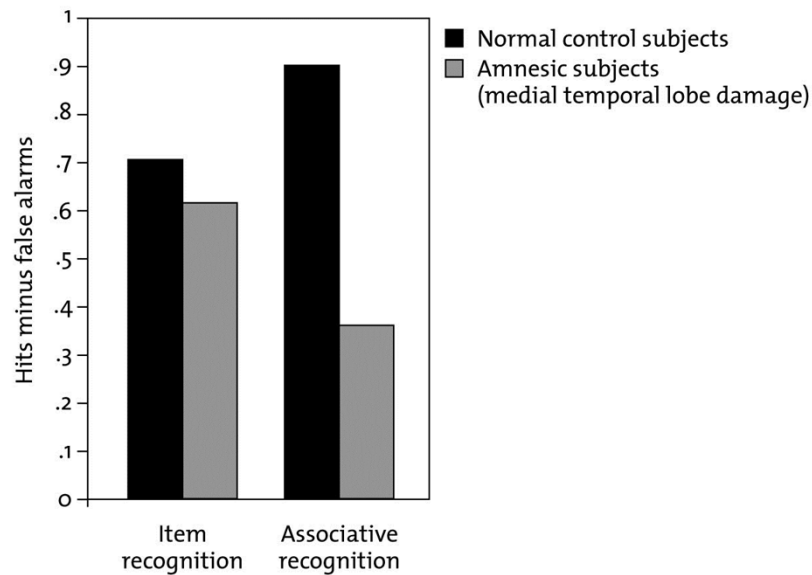
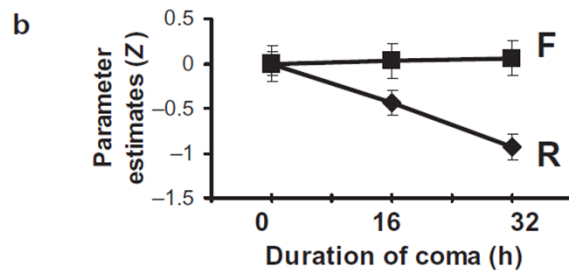
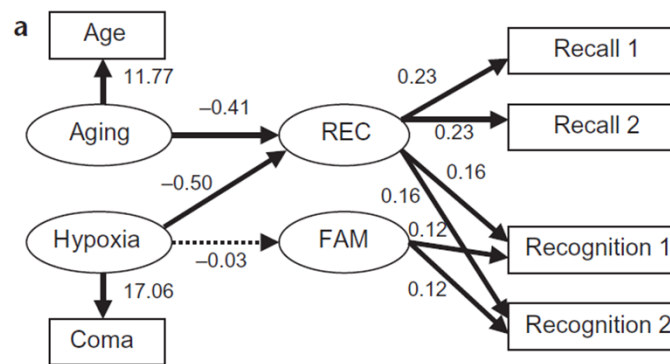


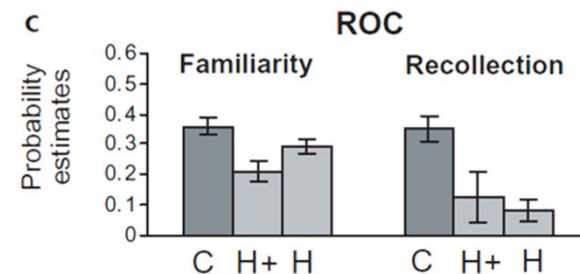
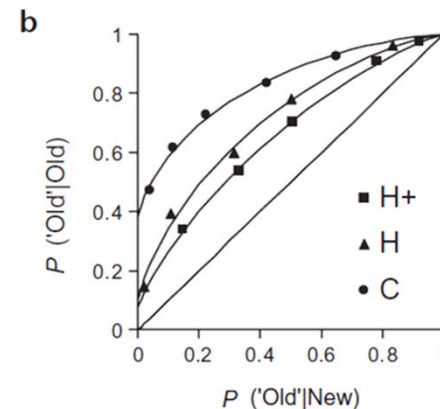
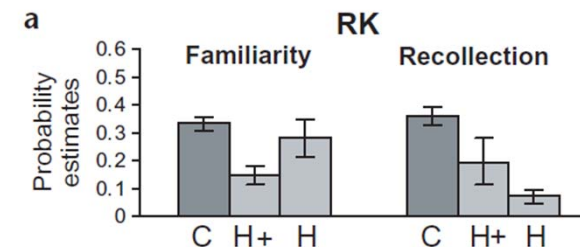
Figure 5. Recognition memory ROCs from amnesics and aged-matched controls (Yonelinas *et al.* 1998).

Hypoxia and the Hippocampus

◆ Temporary loss of oxygen during surgery leads to selective damage of the hippocampus



C : Control
 H : Selective hippocampal damage
 H+: Includes damage to parahippocampal areas



Is that the whole story?

◆ K.C.'s closed head injury (Tulving & Markovitch, 1998)

- Impaired: Retrograde and Anterograde Amnesia
- Preserved: STM, Procedural memory, Semantic memory
 - Learning semantic memories is difficult



Episodic → Semantic Shift
Remember → Know Shift (Rajaram)

Recognition = Recollection + Familiarity



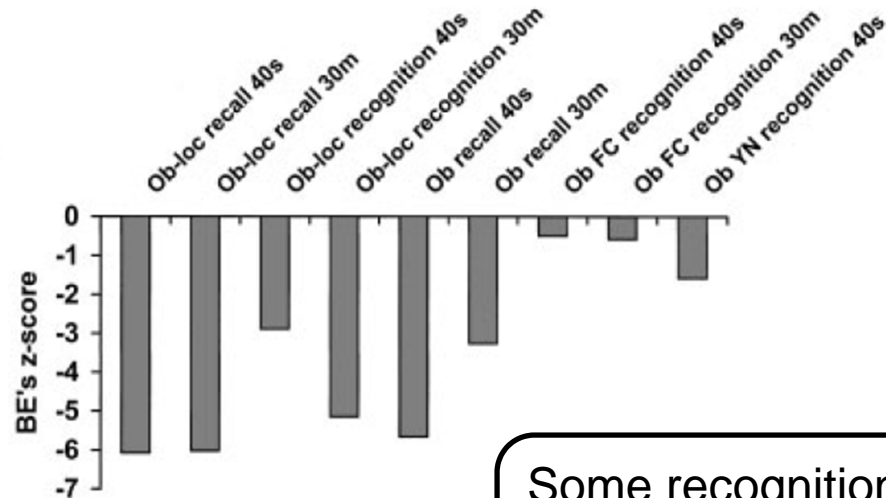
Hippocampal Meta-Analysis

◆ Juliet Holdstock et al. (2002; 2005)

- Selective damage to hippocampus results in recall deficit

Order of Tests Administered in Each Test Session

Order	Task
Session 1	
1	Forced-choice object recognition with 40-s delay
2	Object-location recognition with 30-min delay
3	Yes/no wallpaper pattern recognition
4	Object-location recall after 40-s delay
5	Object recall after 30-min delay
6	Forced-choice wallpaper pattern recognition
7	Recall of the temporal order in which wallpaper patterns were presented
Session 2	
1	Object-location recognition with a 40-s delay
2	Forced-choice object recognition after a 30-min delay
3	Recognition of the temporal order in which wallpaper patterns were presented
4	Object recall with a 40-s delay
5	Object-location recall with a 30-min delay
6	Yes/no object recognition
Session 3	
1	Presentation of picture and topographical memory test stimuli
2	Presentation of story for story recall test
3	Yes/no recognition of line drawn patterns (easy version)
4	Story recall test
5	Recognition memory test with retest
6	Presentation of story for story recognition test
7	Yes/no recognition of line-drawn patterns (moderate version)
8	Story recognition test
9	Forced-choice pattern recognition with remember/know procedure
10	Picture and topographical recognition test



Some recognition tasks can be done with just familiarity.

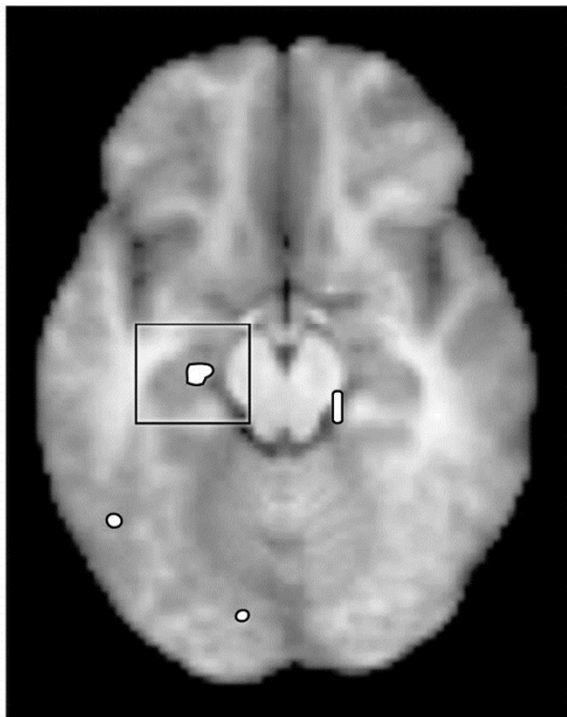


functional Magnetic Resonance Imagery

◆ Remember-Know Paradigm (Eldridge et al., 2000)

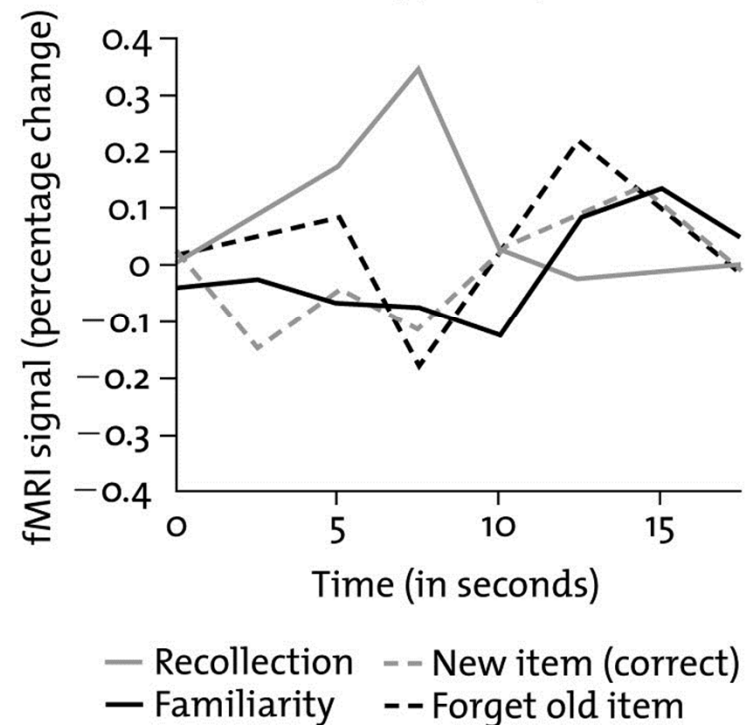
(A)

Recollection

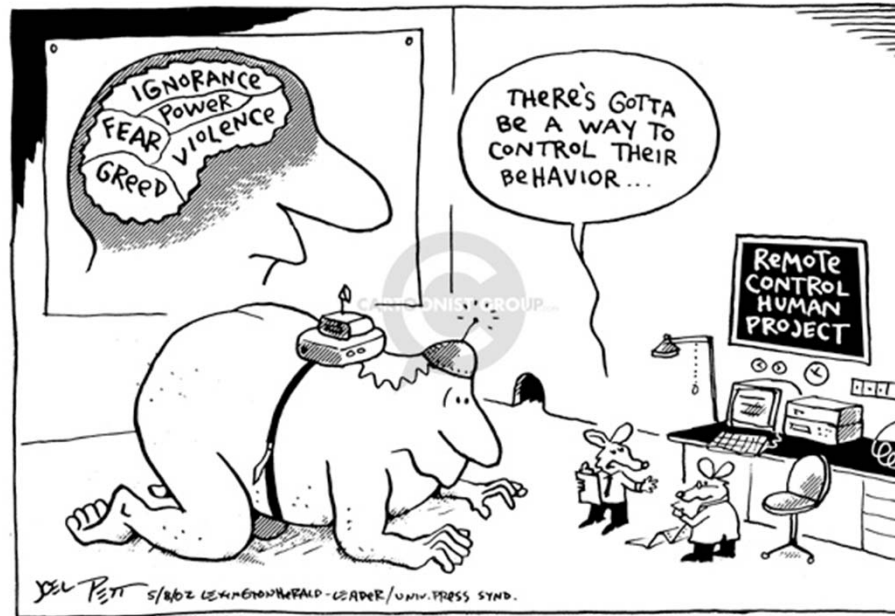


(B)

Left hippocampus



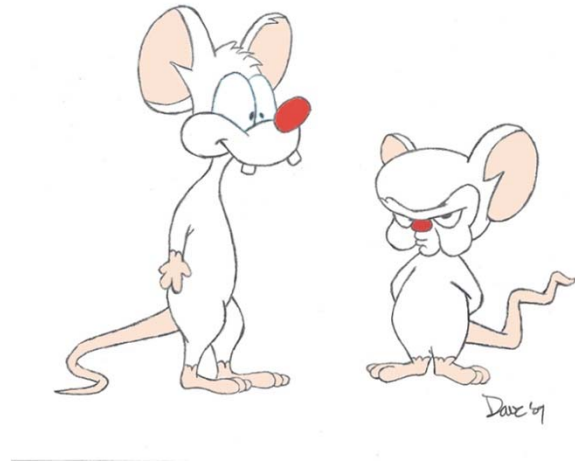
Still Under Debate



- ◆ Larry Squire's data do not agree
- ◆ Difficulties of directly studying hippocampal function in humans
 - Look to animals?

Episodic Memory in Animals

◆ What-Where-When Memory



Acquired in a single experience

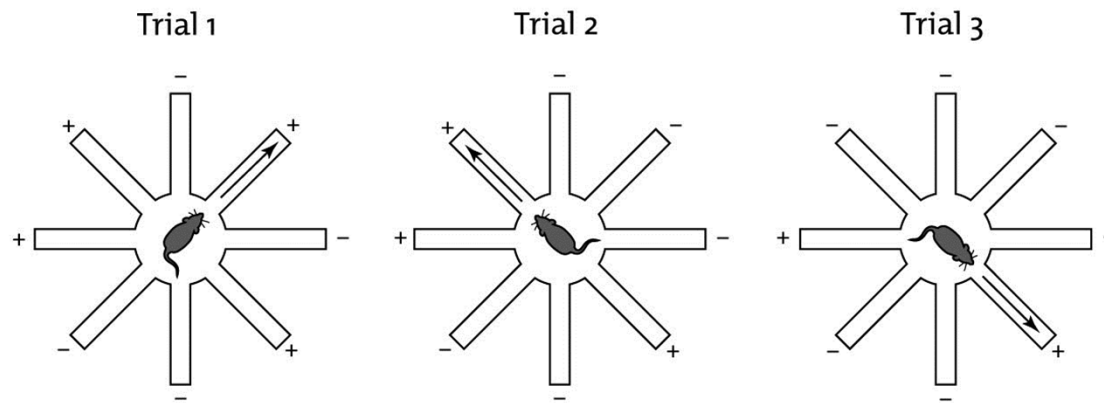
Memory for *where* and *when* something happened

Memory for the order of events in an experience

'What' Memory

◆ Olton's Model of Hippocampal Representation

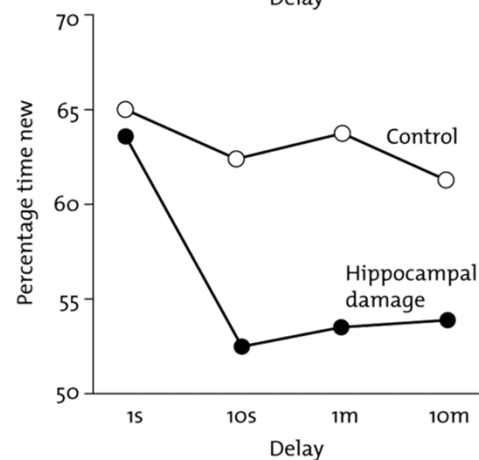
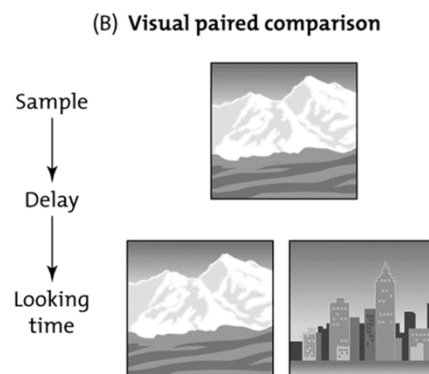
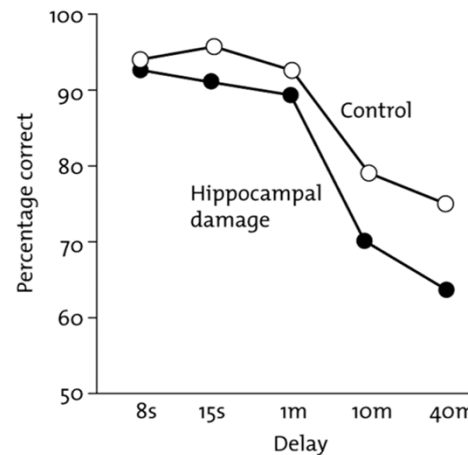
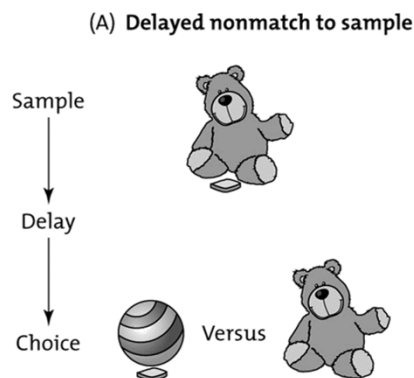
- Unique Events
- Win-Stay (Striatum) vs. Win-Shift (Hippocampus)



'What' Memory

◆ Trial-Unique Delayed Nonmatch to Sample Task

- Monkeys (Mishkin & Delacour, 1975)



Human and Rat ROCs

◆ Yonelinas (2002) ◆ Eichenbaum et al. (1994)

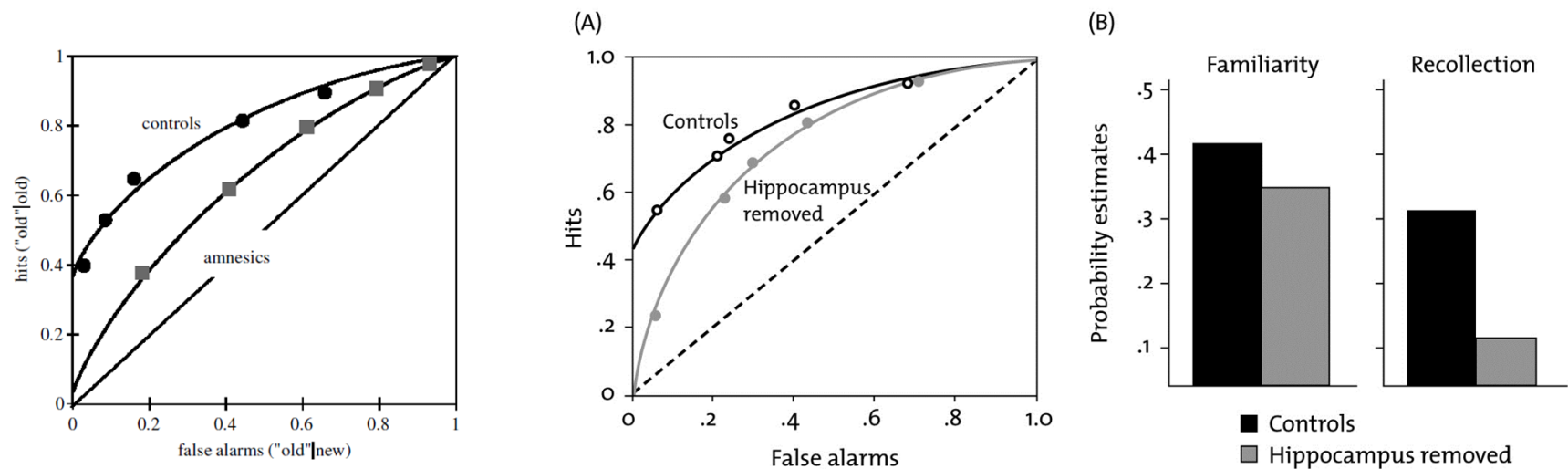
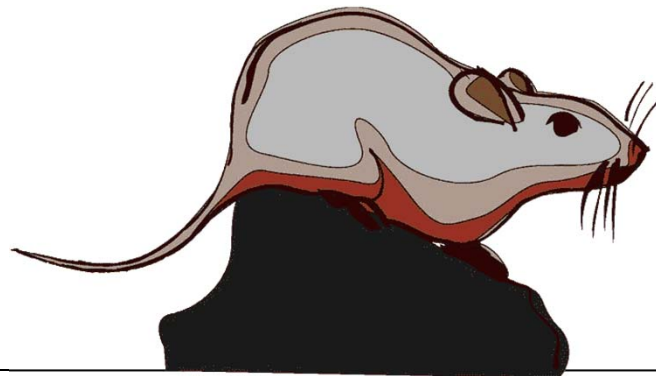


Figure 5. Recognition memory ROCs from amnesics and aged-matched controls (Yonelinas et al. 1998).



'Where' and 'When' Memory

◆ Scrub Jays (Clayton & Dickinson, 1998)

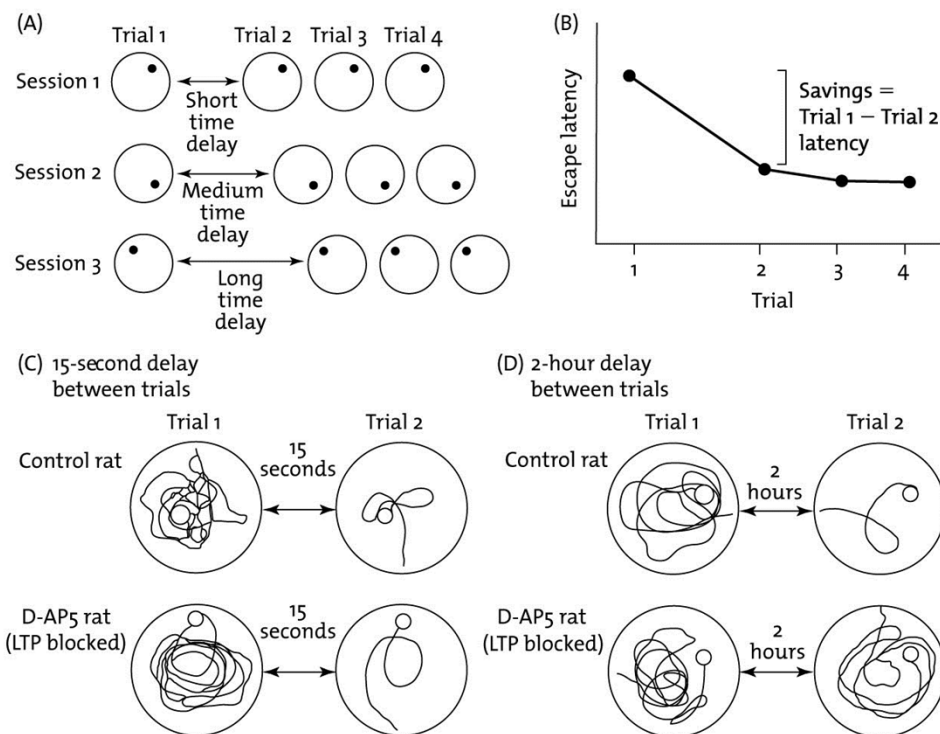
- Worms vs. Peanuts
- Delayed Response



'Where' Memory

◆ Morris Water Maze (Steele & Morris, 1999)

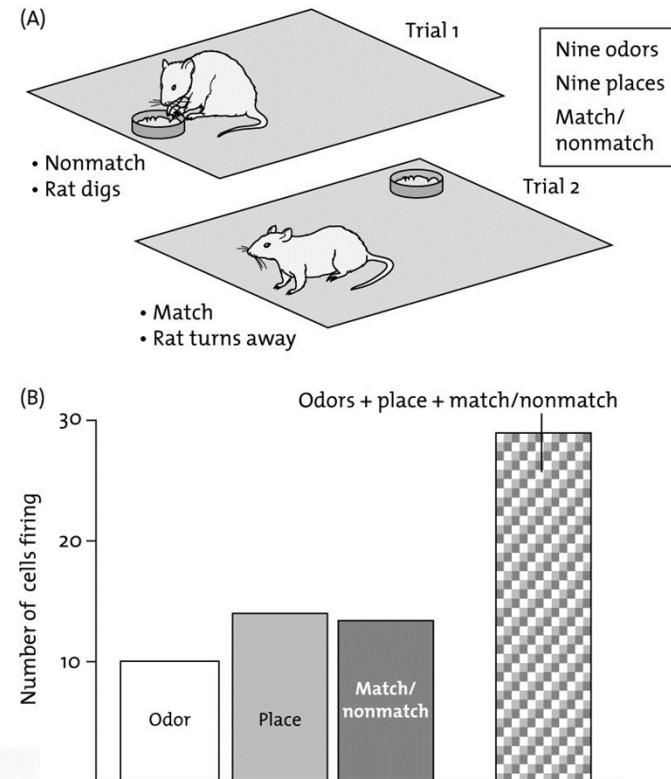
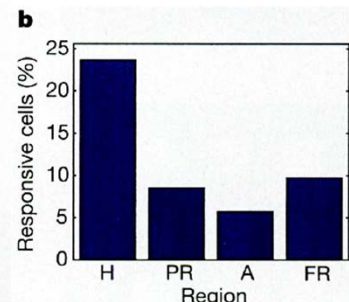
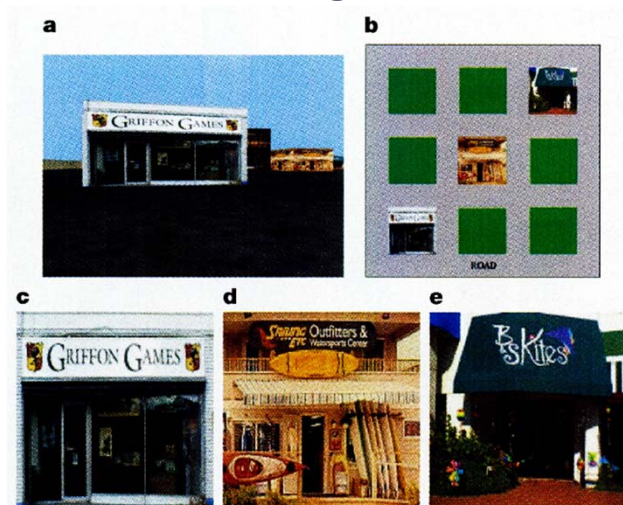
- Escape = Negative
- Positive Rewards (Day et al., 2003)
 - Yummy Rewards



'Where' Memory

◆ Dissociating 'where' memory from 'what' memory

- Rats (Wood et al., 1999)
 - Odors and Locations
- Humans (Ekstrom et al., 2003)
 - Taxi game



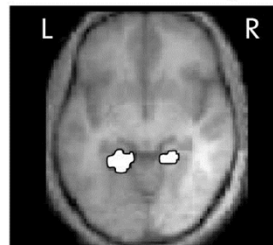
'Where' Memory

◆ Back to humans...

◆ Route (Procedural) vs. Survey (Spatial) Memory

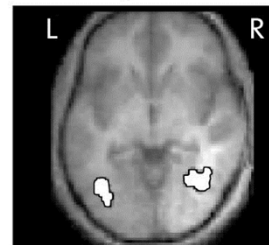


(C) Route > Survey



Route: Other cortical areas,
parahippocampal region,
hippocampus, and occipital

Survey > Route



Survey: Inferior temporal,
posterior parietal, and
occipital

Hippocampus stores sequences of events

Summary

◆ Episodic vs. Other Types of Memory

◆ Amnesiacs

◆ Recollection and Familiarity

- ROC, Remember-Know, Process Dissociation Procedure

◆ Hippocampus

◆ Animal Episodic Memory

- What-Where-When

◆ Neural Representations in Hippocampus

- Spatial?
 - Sequencing
-